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Soil Chemistry and Historic Archaeological Site Activity Areas: A Test Case from Northern Delaware

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ABSTRACT

Varied distributions of soil chemicals were compared to known activity areas at the Wilson-Slack site, a 19th century historic farmstead/blacksmith complex in northern Delaware. Calcium and magnesium were not clearly correlated with specific activity areas. Potassium and phosphorus were not correlated with animal penning areas but were correlated with a machine shop/blacksmithing area. Low pH values were correlated with organic-rich midden deposits.

Introduction

The purpose of this paper is to present a controlled study of the relationship between soil chemistry and activity areas at an historic archaeological farmstead site. Many studies of soil chemistry at prehistoric and historic sites have been undertaken (cf. McManamon 1984 for a review and list of citations). However, in most studies, the interpretation of the varied soil chemistry of sites is based on intuitive notions about how varied activity areas and soil chemistry are related. Also, in many cases analysis of soils from historic sites has been used to substantiate previously perceived spatial patterning of artifacts and activity areas. In this paper the results of a systematic soil chemistry analysis of the Wilson-Slack site, a 19th century farm and agricultural implements workshop complex in northern Delaware (Figure 1) are presented. The presence of standing structures at the site and the use of informant interviews and documentary research allowed activity areas within the site to be delineated prior to the analysis of soil chemistry and artifact distributions. Consequently, it was then possible to compare the relationship between known activity areas and soil chemistry.

Site Background

The Wilson-Slack site was located in Pencader Hundred, New Castle County, Delaware, and was excavated because it was going to be destroyed by highway construction. Initial documentary research (Bachman, _et al._ 1984) had shown the site to be the location of a farmstead and a blacksmith/agricultural implement shop from the mid-19th through early 20th century. Figure 2 shows a map of the site's standing structures at the beginning of the intensive site excavations and Figure 3 shows a photograph of the site. Through informant interviews and documentary analysis (Coleman _et al._ 1985) a painting of the site dating to 1884 was discovered. These data were used to reconstruct three main activity areas at the site: 1) a yard/garden/domestic refuse area to the east of the house; 2) an animal husbandry/food storage area to the north and east of the house; and 3) a workshop/gristmill complex on the extreme eastern end of the site. Analysis of artifact distributions from the test excavations (Coleman _et al_. 1985: 110-121) supported the indentifications of activity areas noted above.

In addition to the excavation of measured test units, more than 300 shovel test pits were excavated across the entire site on a 5-foot grid interval. A 1 liter soil sample was taken from each test pit. Samples were collected from soil horizons immediately beneath the humus horizon. If recent debris, gravels, or construction material were present in the soil at the shovel test pit location, its presence was noted and then these materials were removed before collecting the soil sample. Samples were stored in plastic bags for chemical analysis.

Soil Chemistry Analysis

Soil samples were processed by the University of Delaware College of Agriculture Soils Laboratory and concentrations of calcium, magnesium, potassium, and phosphate were noted, along with soil pH. Lab tests for these chemicals followed standardized procedures used in Delaware, Maryland, and New Jersey, as described by Bandel, *et al.* (1969). The concentrations of these chemicals were studied because each can be linked to specific human alteration of the soil landscape as noted by Birkeland (1974: 59-78).

High levels of phosphate are known to be derived from the deposition of organic wastes due to purposeful manuring or due to the presence of an area where animals were confined by either fences or a structure. Concentrations of potassium are derived from the deposition of wood ash through surface burning or by the dumping of fireplace or stove ash. Calcium concentrations result from agricultural liming, the deposition of oyster shells, or the existence of building materials such as mortar or cement. Magnesium concentrations are affected by most of the processes controlling calcium concentrations, and magnesium is especially elevated if dolomitic limestone fertilizer has been applied. With the pH of a soil sample, readings greater than 7.0 indicate alkaline soils and less than 7.0 would indicate acidic soils. Delaware soils are naturally acidic (Matthews and Lavoie 1970), and readings above 6.0 suggest agricultural liming.

Among the Wilson-Slack site activity areas, the distribution of chemicals were expected to vary. Within the animal husbandry/food storage area high phosphate values were expected from organic wastes. The area of the site that was used for manufacturing and blacksmithing was expected to have increased potassium levels due to the deposition of wood ash. The garden area in the east yard area and the agricultural fields surrounding the north yard area were expected to be differentiated by their calcium and/or magnesium levels from fertilizing.

Figure 4 shows the spatial distribution of the various chemical indices. Soil pH was analyzed first because pH often determines the availability and form of the phosphorous, potassium, calcium, and magnesium ions. The range of pH values was from 4.6 to 7.8 and falls in the moderately acid to weakly basic range. These levels had no effect on the availability and values of the chemicals being tested (Birkeland 1974:21-23). The distribution of pH values in themselves yielded interesting results. The extreme northwestern corner of the site, known to have been in agricultural use, did not show the high values associated with agriculture of liming, and instead had the most acidic soil within the testing area. The east yard area also contained soils more acidic than expected given the known use of this area as a vegetable garden. These anomalous pH values may be due to two factors. First, it is possible that use of organic fertilizers, especially kitchen waste and garbage, in the garden area increased the organic acid content of this area. Second, it is likely that even intensive agricultural liming does <u>not</u> produce the high pH values that archaeologists expect to be associated with agricultural fields and gardens.

Areas of the site that were known not to have been intensively occupied and/or contained low total artifact densities (Coleman *et al*. 1985: Figure 29) had values that indicated changes in the natural acid-base balance. Low values were noted for the area surrounding the blacksmith shop and grist mill and along the road to the south of the site. High values between the house and the barn were closely associated with the distribution of mid to late 19th century ceramics (Coleman *et al*. 1985: Figures 32-33) and more acid soils were probably produced by organic acids associated with the contents of midden deposits.

Two of the elements selected, calcium and magnesium, provided results that were much less informative than expected. The distributions for both elements were extremely similar, with high values concentrated along the edge of the road on the southern border of the site. These high values are probably related to disturbances of soil chemistry associated with modern highway construction and are not related to the archaeological site. A second concentration of high calcium and magnesium values was apparent in the front and the rear of the grist mill. This concentration is related to the presence of buried building materials, such as mortar, bricks, and wood, resulting from the demolition of the grist mill in the 1940s. A corresponding high density of architecture group artifacts, including nails, window glass, and metal fragments, in the same location (Coleman *et al*.

1985:Figure 31) lends support to this conclusion.

The phosphorous distribution shows the suspected division between the domestic and industrial areas. The boundary between the two was sharply defined except in the area of a driveway opening in a fenceline. The sharp division was caused by the fenceline which is known to have existed in this area based on the 1884 painting and on the results of test excavations (Coleman et al. 1985:91) which located a series of fence post molds. The concentration of high phosphorus values east of the blacksmith shop coincided perfectly with the location of the non-extant grist mill/machine shop. The processing of foodstuffs, such as wheat and corn, high in carbohydrates and other organic components, was responsible for the elevated values. Historical and archaeological research also provided an explanation for the high phosphorus concentration northeast of the house. The area partially coincides with a series of trash midden deposits located between the house and the barn (Coleman et al. 1985: 90-95). The phosphorous density indicates that a part of the midden received a higher percentage of raw garbage and other organic wastes than did other areas of the midden. The distribution of phosphorous did not show the sharp distinction that was expected in the rear (north) yard resulting from animal penning. It was anticipated that high concentrations would be present adjacent to the chicken house and to the rear of the granary and privy, due to the presence of manure and other organic wastes. However, no such concentration was seen indicating that even though these waste materials were present, they did not have major effects on the soil chemistry.

The potassium results provided a set of concentrations unique from other chemical concentrations with the exception of a high set of values around the machine shop. Previous soils research has shown that potassium concentrations were caused by the deposition of wood ash (Hurry and Kavanagh 1983). In the one area of known burning of a frame outbuilding in the north yard no elevated levels were noted. The distribution of potassium did allow the division of the domestic and industrial areas to be made. There also appeared to be a slight correlation between high potassium values and a lowered ph. This was especially evident in the area southwest of the blacksmith shop. The anomally may have been caused by the purposeful dumping of ash as fill in the driveway.

Discussion

Table 1 summarizes the relationships between activity areas and soil chemistry . The concentrations correlated to some degree with the location of the extant and non-extant buildings and midden deposits. However, the association between the activity areas and the soil chemistry concentrations was not as precise as may have been anticipated or assumed by some researchers. The associations noted between some of the soils chemicals and activity areas were often vague especially for calcium and magnesium. Furthermore, some expected high concentrations of potassium and phosphorus were not encountered in the yard and animal penning areas, but were present in the machine shop/grist mill area. In this study, low pH values were seen as indicative of organic-rich midden areas and potassium and phosphorus were most indicative of blacksmith/machine shop areas.

The important point to note is that at the Wilson-Slack site, the locations of specific activity areas were known from informant interviews, a contemporary painting, and artifact distributions. It is certain that activities, presumably associated with the disturbance of natural soil chemistry, took place. Yet, there is not always definite evidence for these activities in the empirical soil chemsitry data. Archaeologists using soil chemical analyses clearly cannot assume that activities such as agricultural liming and deposition of organic waste always alter soil chemistry to a sufficient extent to allow its detection by standard analytical tehcniques. In sum, the Wilson-Slack site soil analysis provides a calibration for chemical analysis by correlating known activity areas with variable soil chemistry. Local soil conditions may make the results somewhat specific to certain regional soil settings and additional studies similar to this one are recommended.

ACKNOWLEDGEMENTS

Excavations and soil testing were funded by the Delaware Department of Transportation and the Federal Highway Administration. We thank Alice Guerrant and Dan Griffith of the Delaware Bureau of Archaeology and Historic Preservation, Leo Cotnoir of the University of Delaware College of Agriculture Soils Laboratory, and Keith Doms of the University of Delaware Center for Archaeological Research for their assistance.

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TABLE 1

SOIL CHEMISTRY AND ACTIVITY AREAS

Activity Area	Chemical Pattern and Comment
1)Yard/Garden/Domestic	pH - Low (expected to be high from liming ,was low due to organic waste)
	Ca - nc
	Mg - nc
	P - nc
	K - nc (expected to be high)
2)Animal Husbandry/ Food Storage	pH - nc
	Ca - nc
	Mg - nc
	P - nc (expected to be high)
	K - nc
3)Machine Shop/ Grist Mill	pH - nc
	Ca - nc
	Mg - nc
	P - High (expected to be high)
	K - High (expected to be high)

nc - No Concentration or Anomalous Value

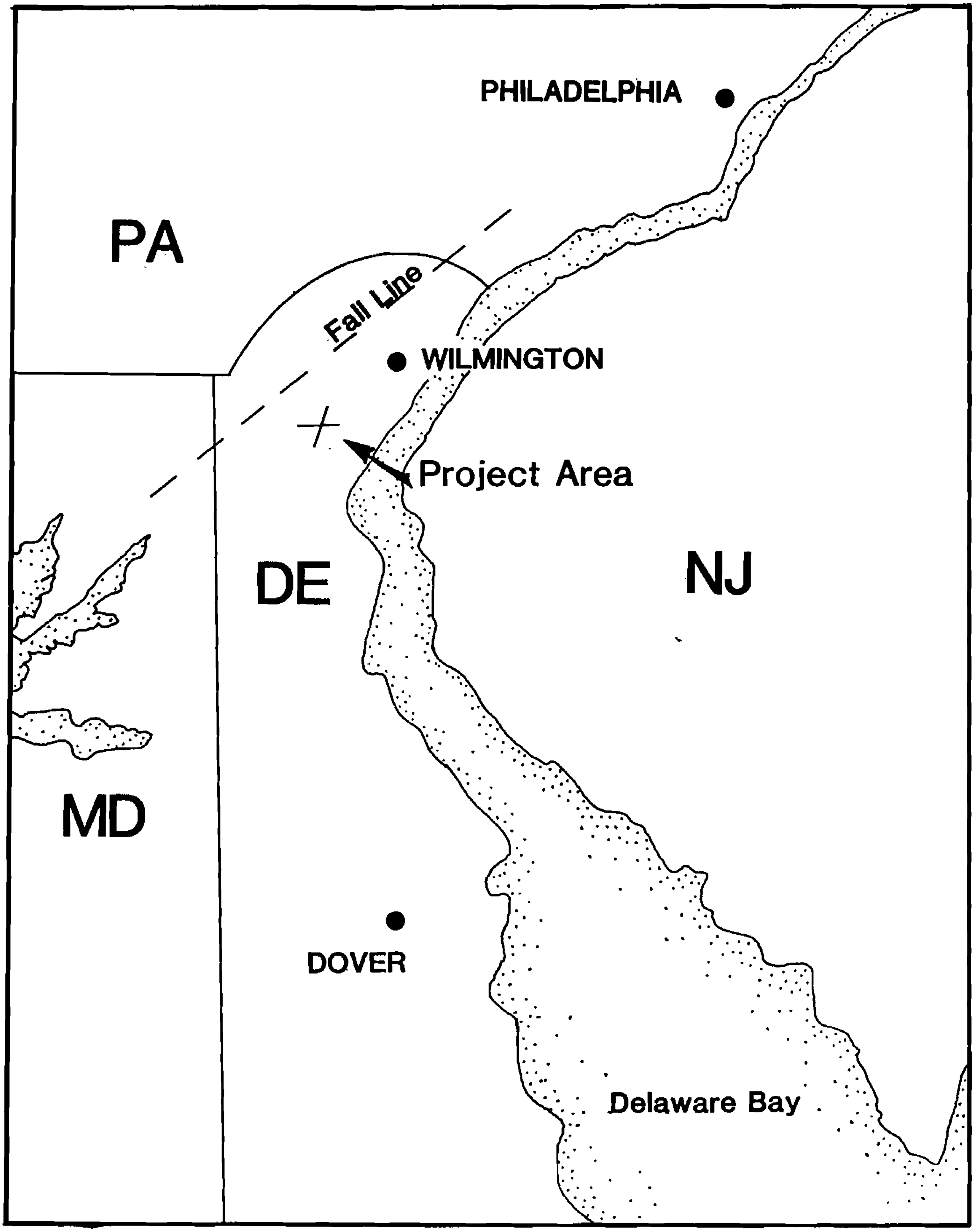
Figure Captions

Figure 1: Map of northern Delaware showing location of Wilson-Slack site

Figure 2: Wilson-Slack site plan showing activity areas

Figure 3: Air view of the Wilson-Slack site

Figure 4: Soil chemical distributions for pH, calcium, magnesium, phosphorus, and potassium


PHILADELPHIA
PA
Fall Line
WILMINGTON
Project Area
DE
NJ
MD
DOVER
Delaware Bay

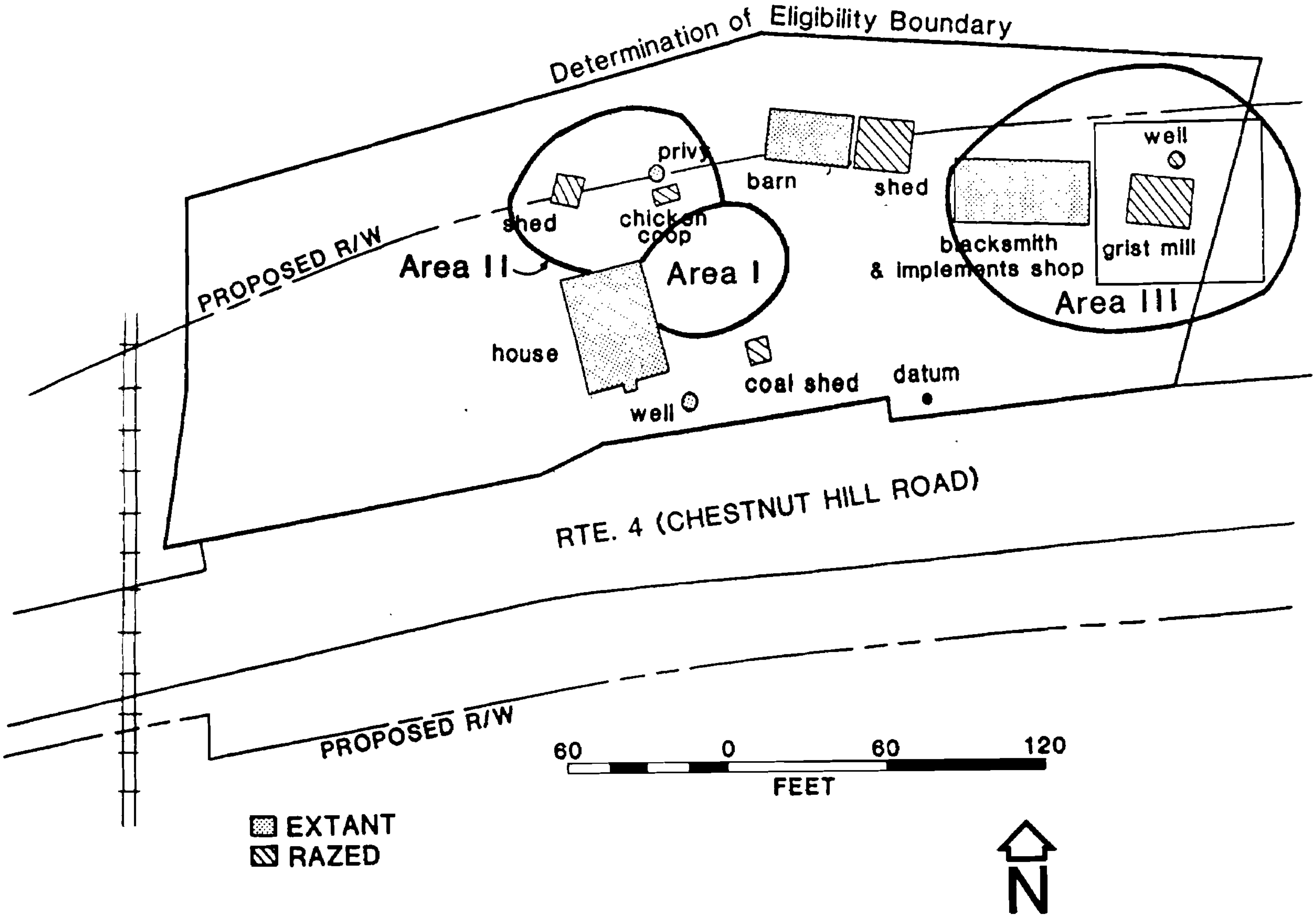
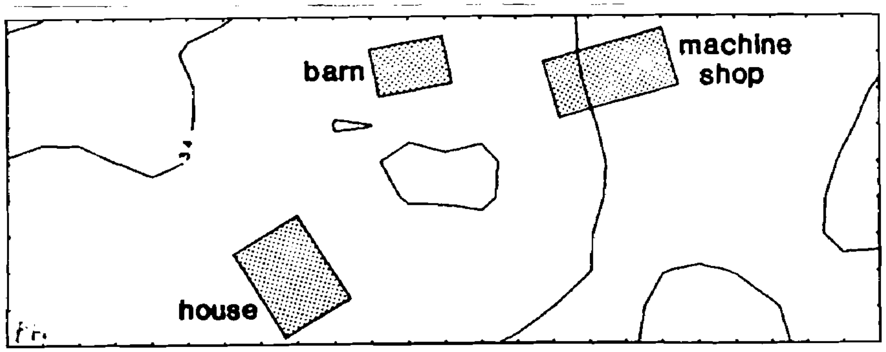
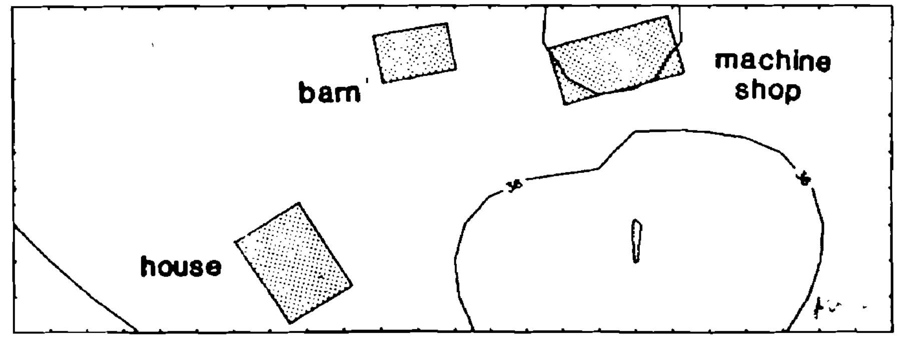

Determination of Eligibility Boundary
privy
barn
shed
well
shed
chicken coop
PROPOSED R/W
Area II
Area I
blacksmith & implements shop
grist mill
Area III
house
coal shed
datum
well
RTE. 4 (CHESTNUT HILL ROAD)
PROPOSED R/W
60
0
60
120
FEET
EXTANT
RAZED
N

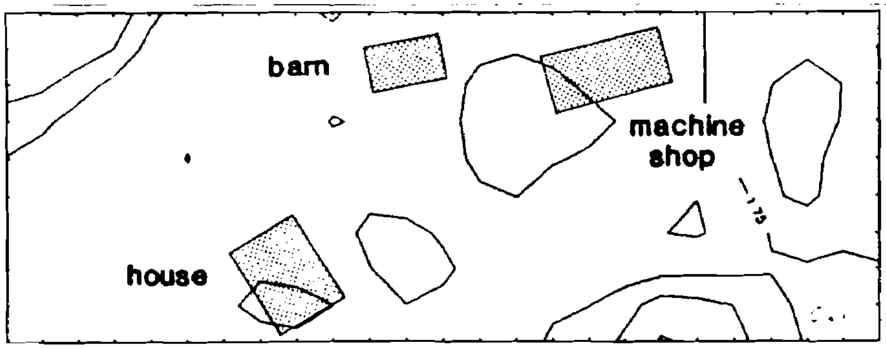
FIG. 2



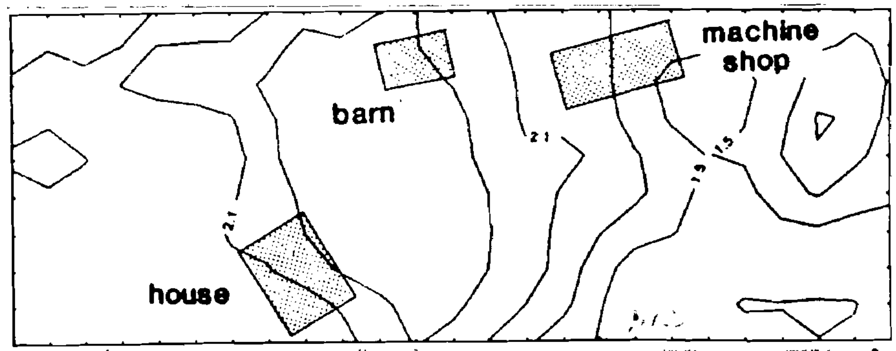
pH



Magnesium

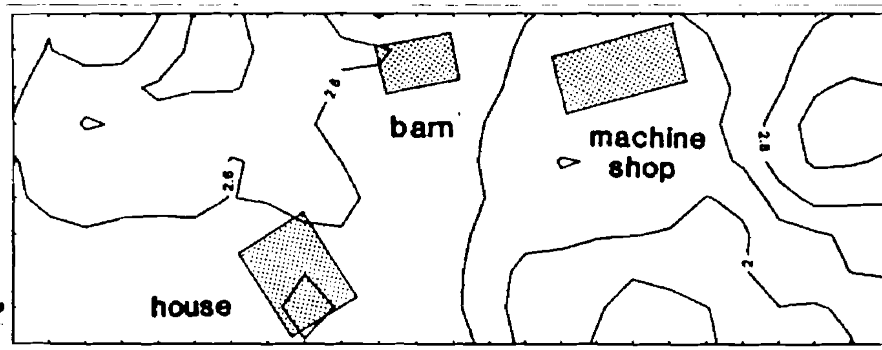


Calcium

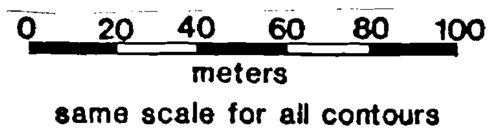


Phosphorus

contours represent indices,
not actual values



Potassium



Evaluation of: Soil Chemistry and Historic Archaeological Site Activity Areas: A Test Case From Northern Delaware

I do not think this article, as written, is suitable for publication in HA (or any other journal for that matter) because of three major faults.

1. This article sets itself as a control study on the use of soil chemistry to delineate activity loci at a historical farmstead site yet fails to include but a single vague sentence describing the methodology used in the field to make the collection nor a single statement as to the laboratory tests involved. In order for readers to evaluate the laboratory results, or to make sense of the findings they must have some knowledge on the sample gathering techniques and the attendant logic involved. Without such details the conclusions are meaningless. Why publish meaningless conclusions?

2. The article fails to draw any but the most obvious conclusions and totally ignores discussion of the reasons why so many unexpected results were encountered. The paper is rife with pregnant sentences, but few deliveries are made. I'm always somewhat suspicious of research results (especially those using chemical analyses) wherein more unexpected than expected things occur. It makes me wonder about the sample. Without a lot more details (and the specified methodology as discussed under 1. above) this article is of no real use to an archaeologist setting about to do a soil chemistry/activity loci study of their own site. I want to know why there were so many inconsistencies!

3. There are not enough details throughout the paper. For instance pg. 6 para 1 the authors state "The concentration is related to the presence of buried building materials.... A corresponding high density of architecture group artifacts in the same location lends support to this conclusion." What building materials, what architecture group artifacts?

3. (continued) The reader wants to know, nay <u>needs to know</u>. How else can the results be evaluated.

One extra point: Most of the figures are unnecessary and/or irrelevant.

In short, it is my feeling that this is the sort of paper that results when an archaeologist does a CRM report gathers in their paycheck and then decides to have the report do double duty. "Hey, let's send the soil chemistry section off to <u>Historical Archaeology</u>. It can't help but fly, its technical."

Unfortunately there isn't a whole lot here which is useful. Redo it and we will see.

RE: Custer et al manuscript

Sorry to take so long on this but I've really been bogged down in academics. I found the paper to be an interesting technical report on the interpretation of soil chemistry patterns and have no problems in recommending that it be published. My own experience with using soil chemistry to understand human activity patterns at a couple of pony express stations underlines the importance of such interpretative efforts. At the same time, the paper as it now stands is much too long for the amount of information that it contains; the biggest problem is the large set of graphics. The paper best fits into the "Research Notes and Comments" section and should be shortened accordingly. Eliminating most of the graphics would take nothing away from the paper and would make the condensation task much easier. Note to authors: I found orthophosphates and total carbon to be useful as well - were these considered? Actually, orthophosphates tended to co-vary with total phosphorus.

This is an interesting study which should be accepted for publication. Documentation of activity areas with chemical analysis of soils is relatively scarce in the literature.

The value of the paper would be greatly increased by the following changes:

1. Give actual values for pH, Ca, Mg, P and K in the text, Table 1 and Figures 6-10. Inclusion of actual values would be quite valuable to other researchers doing comparable work. Also, are the values given for phosphorous from phosphate or the element phosphorous?

2. Sharpen up the discussion of expected results (p. 4-7) to some extent. This could be done in a 1-5 order (pH, Ca, Mg, P, K) to compare to Figures 6-10.